Knowledge Clusters – Rivals in Innovation:
The Life Sciences Industry

MERIC analyzed the U.S. Patent and Trademark Office data for all of the patents issued to originators within the 318 Metropolitan Statistical Areas (MSA) in the U.S. between 1995 and 1999 to determine (1) what groups of patent classes constitute a knowledge cluster, (2) which knowledge clusters Missouri's MSAs compete well in, and (3) which MSAs are in direct competition with St. Louis and Kansas City in the generation of new knowledge.

Key Findings:

Nine knowledge clusters were identified in life sciences and organic chemicals production. These include:

1. *Organic Pharmaceutical Chemistry and Manufacturing*
2. *Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing*
3. *Surgical Processes, Techniques and Apparatus*
4. *Materials Coating Processes*
5. *Mineral Oil and Hydrocarbon Suspension Manufacturing*
6. *Chemical Fertilizer Production*
7. *Crop Planting, Harvesting and Threshing*
8. *Synthetic Hydrocarbon Production and*
9. *Synthetic Fuel Chemistry.*

Missouri generates more patents in the *Organic Pharmaceutical Chemistry and Manufacturing*, *Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing*, and *Surgical Processes, Techniques and Apparatus* than in any other life sciences and organic chemicals knowledge cluster. Missouri's level of innovation in these three clusters ranks its MSAs among the top third in the nation.

However, this level of innovation is not reflected in increased national market share for Missouri's health care and chemical manufacturing industrial sectors.

Knowledge Clusters – Rivals in Innovation: The Life Sciences Industry

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Overview:

MERIC analyzed the U.S. Patent and Trademark Office data for all of the patents issued to originators within the 318 Metropolitan Statistical Areas (MSA) in the U.S. between 1995 and 1999. This was done to determine (1) what patent classes group together to constitute a knowledge cluster, (2) which knowledge clusters Missouri's MSAs compete well in, and (3) which MSAs in other states are in direct competition with Missouri's MSAs in the generation of new knowledge. Nine knowledge clusters were identified in life sciences and organic chemistry. The names of these clusters are derived from the patent classes that grouped together. The nine life sciences and organic chemistry clusters include:

1. *Organic Pharmaceutical Chemistry and Manufacturing*
2. *Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing*
3. *Surgical Processes, Techniques and Apparatus*
4. *Materials Coating Processes*
5. *Mineral Oil and Hydrocarbon Suspension Manufacturing*
6. *Chemical Fertilizer Production*
7. *Crop Planting, Harvesting and Threshing*
8. *Synthetic Hydrocarbon Production and*
9. *Synthetic Fuel Chemistry.*

MERIC calculated the number of patents per 100,000 population in each of these patent clusters for all 318 MSAs. Missouri produced more patents in *Organic Pharmaceutical Chemistry and Manufacturing*, *Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing*, and *Surgical Processes, Techniques and Apparatus* than in any other life sciences and organic chemistry knowledge cluster. Missouri's level of innovation in these three clusters places its MSAs among the top third in the nation. A detailed list of the patent classes which constitute each cluster is presented in the Appendix.

Objectives:

The first objective of this study is to identify knowledge clusters using only public data sources, and allow that data to dictate which patent classes should be linked together. This technique is limited by the types of patents actually being applied for during the five years studied, but it makes up for this limitation by linking types of knowledge actually being developed in the same place at the same time.

The second objective is to determine how Missouri's efforts in innovation correspond with Missouri's "cash crop" industries. Are Missouri's knowledge cluster patents being explored and exploited to help its businesses sell more goods and services to other states than it buys from them? In which industries and knowledge clusters could Missouri begin to do this more effectively?

Method:

A database was constructed using data from the U.S. Patent and Trademark Office web site to reflect the number of patents issued between 1995 and 1999 for each of the 318 MSAs by patent class. Cluster analysis and factor analysis were used in combination to group the patent classes. Patent classes were organized so that patent types being generated in the same geographic area would group together as knowledge clusters. In this way a publicly available database is used to determine the structure and components for knowledge clusters. The only assumption in this analysis is that innovation in different patent classes is based upon an understanding of more basic theoretical principles. The understanding of theoretical principles is geographically bound therefore those patent classes with highly correlated locations of origin must share a common knowledge structure. Discovery of both the underlying knowledge structure and the geographic location where those structures are located result from the data analysis undertaken.

Missouri's Niche in the Life Sciences:

Table 1 shows that much of Missouri's current efforts in innovation are directed towards the life sciences. Between 1995 and 1999, 28% of the patents generated in St. Louis, 19% of the patents generated in Kansas City, and 38% of the patents generated in Columbia were in life sciences and organic chemistry related patent classes.

Table 1: Patent Clusters with the Most Patents Issued 1995 to 1999

St. Louis MO-IL MSA	**Percent**
Packaging, Dispensing and Exhibiting Products	13.70%
Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing	10.61%
Organic Pharmaceutical Chemistry and Manufacturing	10.05%
Electrical Heating Devices Manufacture	5.24%
Surgical Processes, Techniques and Apparatus	5.24%
Fluid Materials Handling and Refrigeration	4.96%
Electromagnetic Wave and Laser Communications	4.18%
Measurement and Calibration Instrument Manufacturing	3.49%
Materials Coating Processes	1.81%
Motor Vehicle Manufacturing	1.81%
Percent of St. Louis Patents between 1995 and 1999	**61.09%**

Kansas City MO-KS MSA	**Percent**
Surgical Processes, Techniques and Apparatus	9.14%
Packaging, Dispensing and Exhibiting Products	6.22%
Electrical Heating Devices Manufacture	5.56%
Fluid Materials Handling and Refrigeration	5.37%
Organic Pharmaceutical Chemistry and Manufacturing	5.00%
Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing	4.81%
Electromagnetic Wave and Laser Communications	4.52%
Motor Vehicle Manufacturing	4.43%
Cryptography, Artificial Intelligence and Computer Speech	3.96%
Printing	3.11%
Percent of Kansas City Patents between 1995 and 1999	**52.12%**

Columbia MO MSA	Percent
Organic Pharmaceutical Chemistry and Manufacturing	19.33%
Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing	10.08%
Fluid Materials Handling and Refrigeration	10.08%
Surgical Techniques and Apparatus	8.40%
Packaging, Dispensing and Exhibiting Products	6.72%
Measurement and Calibration Instrument Manufacturing	5.04%
Motor Vehicle Manufacturing	4.20%
Cryptography, Artificial Intelligence and Computer Speech	3.36%
Television and Digital Image Processing	2.52%
Electrical Computer Manufacturing and Process Coordination	1.68%
Percent of Columbia Patents between 1995 and 1999	**71.34%**

Paraphrasing Dr. Michael Porter's work on using knowledge clusters to enhance regional prosperity: *You must use what you have, in terms of the existing industrial base and innovative capacity, to build what you need. Without ignoring any business sector, concentrate on those sectors that are exporting more goods and services to the rest of the nation than they are importing into the state.* The location quotient is one measure of this distinction between industrial sectors.

Missouri's Export Industries (To Other States):

A location quotient greater than one (1.0) indicates that the level of employment in that industry exceeds the level necessary to satisfy the local demand for the goods or services which it produces. The location quotient thus measures the portion of an industry's workforce in excess of that used to supply the needs of the local market. The long-term projections model, used by the U.S. Department of Labor, Bureau of Labor Statistics, uses a threshold value of 1.2 to distinguish those industries which primarily supply local demand from those that export goods and services to the rest of the nation. This takes into account the circumstance where some local industries may have larger employment concentrations compared to the nation, but are still primarily local serving. Comparison of the location quotients for a given industry across all of the states will provide a representation of the market share of that industry captured and supplied by each state with a location quotient greater than 1.2.

Table 2 presents by two-digit SIC code those Missouri industries with the highest location quotients. Using "Communications" to illustrate how to read this table, the location quotient of 1.5 indicates that .3 (1.5-1.2) of the indicator is engaged in export outside the state. This means that 20% (.3/1.5) of communications industry workers in Missouri are engaged in supplying export goods and services to other states. The "Health Services" and "Chemicals and Allied Products" industries correspond most closely to Missouri's most innovative life sciences and organic chemistry knowledge clusters. Yet their location quotients are only 1.23 and 1.18 respectively. This indicates that although Missouri is engaged in innovation in the life sciences and organic chemistry clusters, those innovations are not currently being converted into products that allow Missouri to capture a greater share of the life sciences and organic chemistry market.

Table 2: Missouri's Top 20 Export Industries (To Other States)

SIC Code	SIC Title	Location Quotient	Percent of Wages Paid
3100	Leather and Leather Products	2.30	0.115%
1400	Nonmetallic Minerals, except Fuels	1.55	0.163%
4800	Communications	1.50	2.614%
2000	Food and Kindred Products	1.48	2.613%
3700	Transportation Equipment	1.48	3.401%
4000	Railroad Transportation	1.44	0.001%
4200	Trucking and Warehousing	1.41	2.005%
6200	Security and Commodity Brokers	1.30	1.674%
2700	Printing and Publishing	1.29	1.700%
5500	Automotive Dealers & Service Stations	1.27	2.010%
2500	Furniture and Fixtures	1.26	0.555%
5300	General Merchandise Stores	1.24	1.499%
4300	U.S. Postal Service	1.23	1.012%
8000	Health Services	1.23	9.280%
1000	Metal Mining	1.19	0.045%
2800	Chemicals and Allied Products	1.18	1.627%
7900	Amusement & Recreation Services	1.15	1.211%
8600	Membership Organizations	1.15	0.487%
4900	Electric, Gas and Sanitary Services	1.13	1.441%
3400	Fabricated Metal Products	1.12	1.416%

The Location Quotient is based on 2000 employment data. The Percent of Wages Paid is based on 2001 covered employment and wage data.

The Competition in Life Sciences:

There are 318 Metropolitan Statistical Areas (MSA) in the U.S. The rankings of the 6 Missouri MSAs and the clusters in which they are most involved are presented in Tables 3, 4 and 5 (all rankings are of patents per 100,000 population.). Although the number of patents per 100,000 population generated by Missouri's MSAs may seem small, the rankings of Columbia, St. Louis and Kansas City indicate that concerted effort can increase the relative standing of Missouri's MSAs in life sciences. In a previous report, MERIC investigated which MSAs had grown fastest in their overall generation of patents (see *Innovation Clusters in the Decade of the 1990s*, January 2002). Six of the eighteen fastest growing MSAs in terms of overall patent development between 1990 and 1999 ranked high in the generation of life sciences patents (San Jose CA, Rochester MN, Boulder-Longmont CO, Corvallis OR, San Francisco CA and Yolo CA).

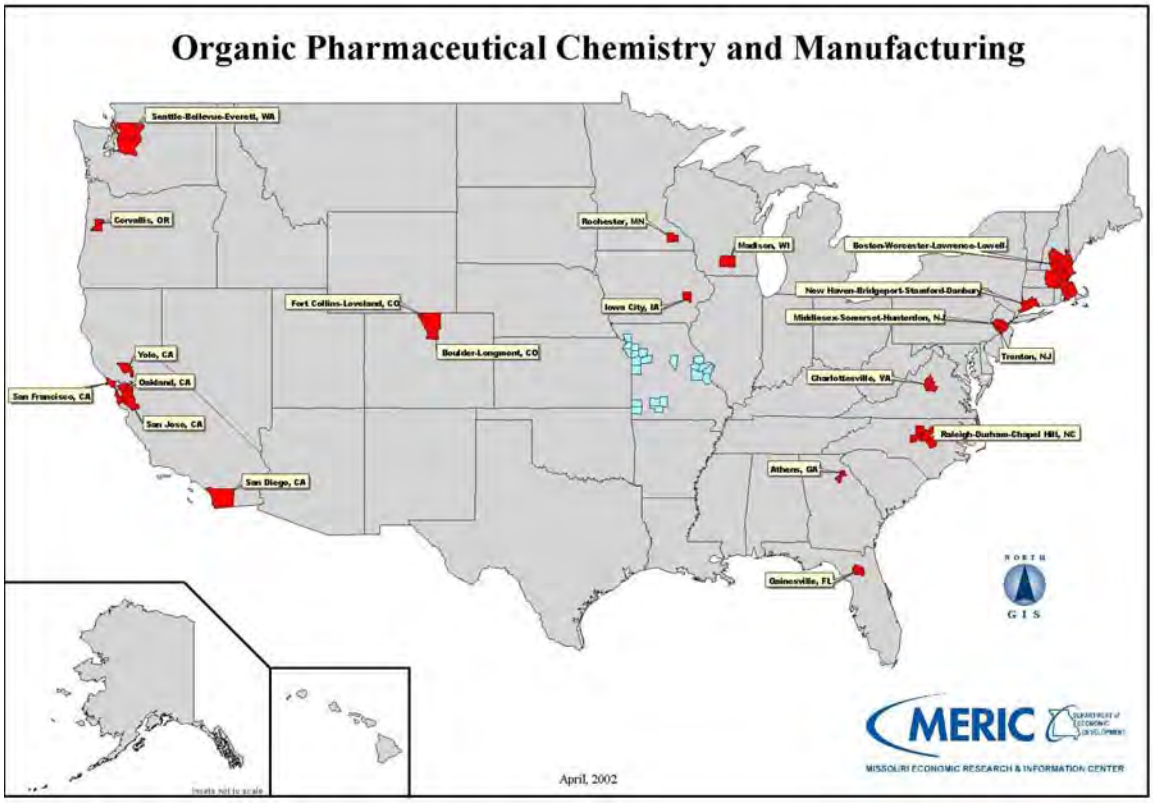

Table 3: Patent Rankings in Organic Pharmaceutical Chemistry

Organic Pharmaceutical Chemistry and Manufacturing	**Patents per 100,000**	**# of 318**
Yolo CA PMSA	101.08	1st
Boulder-Longmont CO PMSA	85.82	2nd
San Francisco CA PMSA	68.68	3rd
San Jose CA PMSA	63.25	4th
Trenton NJ PMSA	58.63	5th
Madison WI MSA	53.34	6th
Iowa City IA MSA	52.85	7th
Gainesville FL MSA	48.67	8th
San Diego CA MSA	45.84	9th
Middlesex-Somerset-Hunterdon NJ PMSA	45.29	10th
Missouri's MSAs		
Columbia MO MSA	18.08	33rd
St. Louis MO-IL MSA	12.60	44th
St. Joseph MO MSA	4.11	123rd
Kansas City MO-KS MSA	3.09	138th
Joplin MO MSA	0.00	283rd
Springfield MO MSA	0.00	308th

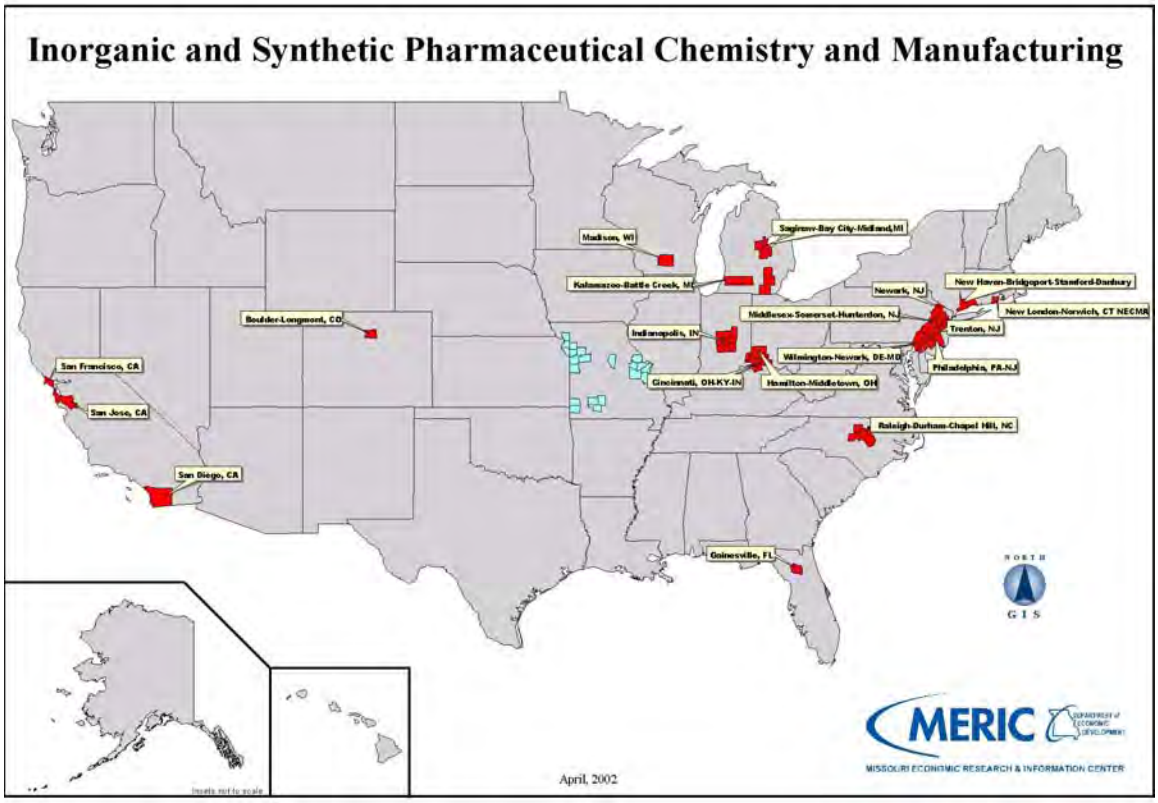

Table 4: Patent Rankings in Synthetic Pharmaceutical Chemistry

Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing	**Patents per 100,000**	**# of 318**
Trenton NJ PMSA	99.42	1st
New London-Norwich CT NECMA	74.61	2nd
Middlesex-Somerset-Hunterdon NJ PMSA	63.04	3rd
Wilmington-Newark DE-MD PMSA	58.28	4th
Indianapolis IN MSA	50.83	5th
Gainesville FL MSA	45.12	6th
Ann Arbor MI PMSA	36.92	7th
Madison WI MSA	31.19	8th
Kalamazoo-Battle Creek MI MSA	30.15	9th
Philadelphia PA-NJ PMSA	28.78	10th
Missouri's MSAs		
St. Louis MO-IL MSA	13.30	26th
Columbia MO MSA	9.43	41st
Kansas City MO-KS MSA	2.97	94th
Springfield MO MSA	0.66	196th
Joplin MO MSA	0.00	277th
St. Joseph MO MSA	0.00	311th

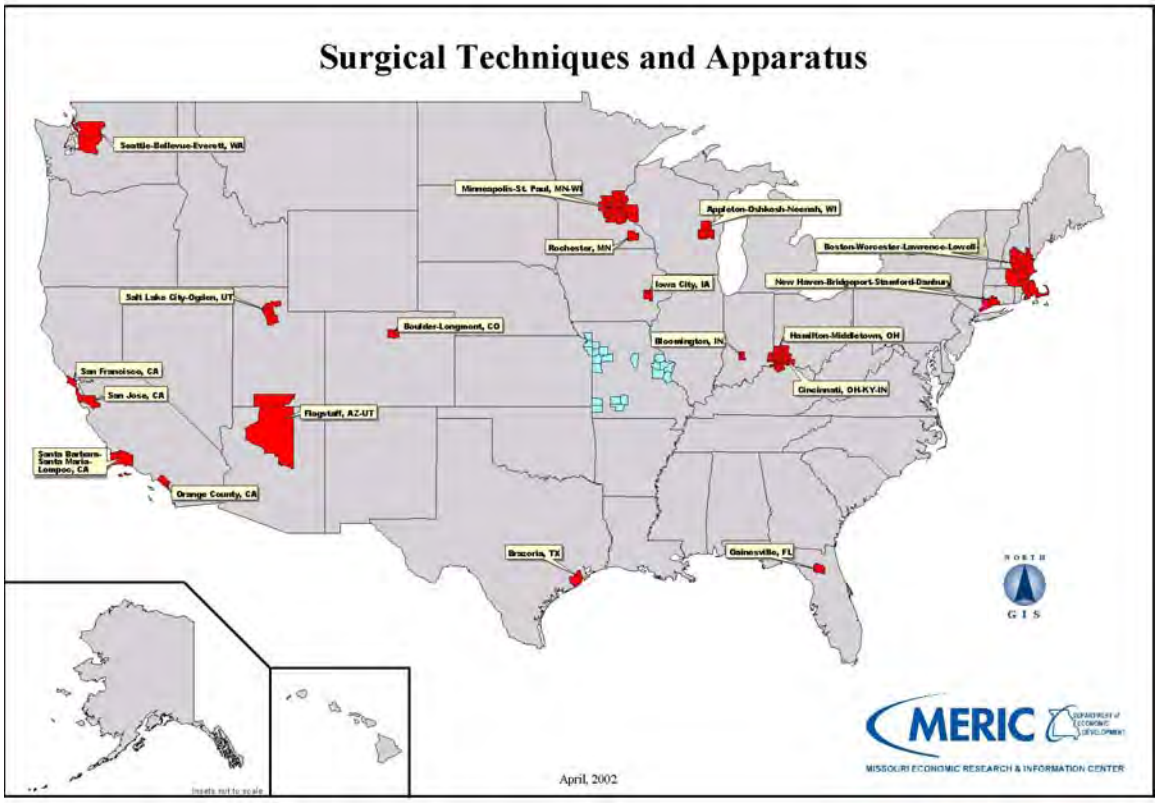

Table 5: Patent Rankings in Surgical Processes, Techniques and Apparatus

Surgical Techniques and Apparatus	**Patents per 100,000**	**# of 318**
San Jose CA PMSA	69.13	1st
Minneapolis-St. Paul MN-WI MSA	56.78	2nd
Appleton-Oshkosh-Neenah WI MSA	43.57	3rd
San Francisco CA PMSA	40.97	4th
Brazoria TX PMSA	36.18	5th
Hamilton-Middletown OH PMSA	34.84	6th
Boulder-Longmont CO PMSA	33.95	7th
Rochester MN MSA	32.98	8th
Iowa City IA MSA	31.32	9th
Orange County CA PMSA	30.08	10th
Missouri's MSAs		
Columbia MO MSA	7.86	60th
St. Louis MO-IL MSA	7.47	76th
Kansas City MO-KS MSA	6.06	97th
Joplin MO MSA	2.72	165th
Springfield MO MSA	1.66	213th
St. Joseph MO MSA	0.00	314th

Conclusion:

Missouri generates a large proportion of its patents in life science and organic chemistry related patent classes. Yet the concentration of employment in the health services and chemicals and allied products industrial sectors indicate little application of these patents in the production of products in Missouri. Some of the fastest growing and most innovative cities in the nation have increased their level of innovation in these knowledge clusters during the decade of the 1990s. Life sciences appears to be one area where exploiting the level of innovation already present through the development of marketable goods and services can enhance a local area's level of prosperity.

Appendix:

The locations of origin for the following life sciences and organic chemistry patent classes were sufficiently linked to consider these class groupings as a distinct knowledge cluster.

Organic Pharmaceutical Chemistry and Manufacturing
Class 351 , Optics: Eye Examining, Vision Testing and Correcting
Class 424 , Drug, Bio-Affecting and Body Treating Compositions
Class 435 , Chemistry: Molecular Biology and Microbiology
Class 436 , Chemistry: Analytical and Immunological Testing
Class 530 , Chemistry: Natural Resins or Derivatives; Peptides or Proteins; Lignins or Reaction Products Thereof
Class 536 , Organic Compounds -- Part of the Class 532-570 Series
Class 705 , Data Processing: Financial, Business Practice, Management, or Cost/Price Determination

Inorganic and Synthetic Pharmaceutical Chemistry and Manufacturing
Class 423 , Chemistry of Inorganic Compounds
Class 504 , Plant Protecting and Regulating Compositions
Class 514 , Drug, Bio-Affecting and Body Treating Compositions
Class 534 , Organic Compounds -- Part of the Class 532-570 Series
Class 540 , Organic Compounds -- Part of the Class 532-570 Series
Class 544 , Organic Compounds -- Part of the Class 532-570 Series
Class 546 , Organic Compounds -- Part of the Class 532-570 Series
Class 548 , Organic Compounds -- Part of the Class 532-570 Series
Class 549 , Organic Compounds -- Part of the Class 532-570 Series
Class 558 , Organic Compounds -- Part of the Class 532-570 Series
Class 560 , Organic Compounds -- Part of the Class 532-570 Series
Class 564 , Organic Compounds -- Part of the Class 532-570 Series

Surgical Processes, Techniques and Apparatus
Class 128 , Surgery
Class 433 , Dentistry
Class 600 , Surgery
Class 601 , Surgery: Kinesitherapy
Class 602 , Surgery: Splint, Brace, or Bandage
Class 604 , Surgery
Class 606 , Surgery
Class 607 , Surgery: Light, Thermal, and Electrical Application
Class 623 , Prosthesis (i.e., Artificial Body Members), Parts Thereof, or Aids and Accessories Therefor

Materials Coating Processes
Class 106 , Compositions: Coating or Plastic
Class 252 , Compositions
Class 501 , Compositions: Ceramic
Class 521 , Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series
Class 522 , Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series
Class 523 , Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series
Class 524 , Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series
Class 525 , Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series
Class 528 , Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series
Class 556 , Organic Compounds -- Part of the Class 532-570 Series

Mineral Oil and Hydrocarbon Suspension Manufacturing
Class 208 , Mineral Oils: Processes and Products
Class 502 , Catalyst, Solid Sorbent, or Support Therefor: Product or Process of Making
Class 516 , Colloid Systems and Wetting Agents; Subcombinations Thereof; Processes Of
Class 526 , Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series
Class 562 , Organic Compounds -- Part of the Class 532-570 Series
Class 568 , Organic Compounds -- Part of the Class 532-570 Series
Class 585 , Chemistry of Hydrocarbon Compounds

Chemical Fertilizer Production
Class 071 , Chemistry: Fertilizers
Class 201 , Distillation: Processes, Thermolytic
Class 202 , Distillation: Apparatus
Class 203 , Distillation: Processes, Separatory

Crop Planting, Harvesting and Threshing
Class 056 , Harvesters
Class 111 , Planting
Class 460 , Crop Threshing or Separating

Synthetic Hydrocarbon Production
Class 552 , Organic Compounds -- Part of the Class 532-570 Series
Class 554 , Organic Compounds -- Part of the Class 532-570 Series
Class 800 , Multicellular Living Organisms and Unmodified Parts Thereof and Related Processes

Synthetic Fuel Chemistry
Class 260 , Chemistry of Carbon Compounds
Class 518 , Chemistry: Fischer-Tropsch Processes; or Purification or Recovery of Products Thereof